



ALLIED VEHICLE TESTING PUBLICATIONS

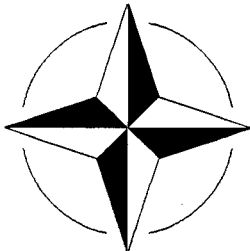
TRIAL SERIES 11

RELIABILITY , AVAILABILITY , MAINTAINABILITY AND DURABILITY (RAM - D)

AVTP	TEST TITLE
11 - 10	Endurance Testing of Wheeled and Tracked Vehicles
11 - 20	Reliability , Availability Maintainability and Durability (RAM - D) Data for Wheeled and Tracked Vehicles

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 11-10
EDITION NO.: FINAL
DATE : OCT 1993



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : RELIABILITY, AVAILABILITY
MAINTAINABILITY AND DURABILITY
(RAM-D)

TEST TITLE : RAM-D TESTING OF WHEELED AND
TRACKED VEHICLES

REFERENCE : STANAG 4357
STANAG 4358
STANAG 4158

EQUIVALENT : ITOP NO.: 2-2-506 (1)
WEU 4FT6 NO.: TM 11-10

FOR COMPLIANCE
WITH : -

ABSTRACT : This document describes procedures
for conducting RAM-D tests of
military wheeled and tracked vehi-
cles over various test courses for
prescribed distances or time.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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5. Recommended changes to or comments on this publication should be forwarded to the secretary AC/225 (Panel II), Land Armaments Section, NATO HQ, 1110 Brussels Belgium.
6. Any ratifying nation may issue supplemental testing information to amplify or clarify these procedures, but in no case will such information contravene the provisions of this AVTP. If a ratifying nation must deviate from a provision of this AVTP due to constraints such as available facilities, national regulations, instrumentation accuracies, etc., the test methods used will be described in the report. However, such deviation may cause nonacceptance of test data by other nations.

FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

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*) See Reservations Overleaf

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Trial Series: RELIABILITY, AVAILABILITY, MAINTAINABILITY AND
DURABILITY (RAM-D)

Test Title : RAM-D TESTING OF WHEELED AND TRACKED VEHICLES

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Test Vehicle
- 3.2 Test Course
- 3.3 Environmental Conditions
4. TEST PROCEDURE
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ANNEX A: DEVELOPMENT OF RAM-D TEST CYCLES

ANNEX B: DURABILITY CONSIDERATIONS

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1. SCOPE

a. This document describes procedures for conducting automotive RAM-D tests of military wheeled and tracked vehicles over various standard test courses for prescribed distances or times.

b. The RAM-D test is the principal means of producing data for reliability, availability maintainability and durability calculations during development tests, and also is a major source of information on technical improvements, and human factors.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

Select appropriate test courses based on vehicle mission. Test courses normally include at least paved and secondary roads, level and hilly cross country and other specific courses (e.g. Belgian Block).

2.2 Instrumentation

<u>DEVICES FOR MEASUREMENT OF:</u>	<u>PERMISSIBLE ERROR OF MEASUREMENT*</u>
a. Vehicle speed	5 %
b. Engine speed (if required)	5 %
c. Distance	2 %
d. Operating time	1 %
e. Contaminant concentrations in fuel and lubricants	2 ppm or 15 % of reading, whichever is larger
f. Temperature	1 °C
g. Pressure	1 %
h. Fuel and oil consumption	2 %
i. Meteorological data	
(1) Ambient temperature	1 °C
(2) Relative humidity	3 %

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* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

a. Ensure that the test vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan. Give particular attention to the engine, transmission, and running gear. The inspection usually is limited to visual and functional inspection of the vehicle, but can be expanded to include more detail, when doubt exists concerning serviceability. Record the model and serial numbers of the vehicle and major components.

b. Ensure that new vehicles have been operated for the appropriate break-in mileage. During this operation, use the vehicle and engine speeds and loads recommended by the manufacturer. When necessary, adjust engine governors for recommended crankshaft speed.

c. Ensure that the vehicle is loaded according to the test plan including the cargo or simulated payload it is designed to carry as well as other authorized equipment such as tools and spare parts unless otherwise specified in test documents. Simulate the weight for vehicle crew members other than the operator. Secure loads adequately to prevent shifting, and instruct the operators concerning special hazards as necessary. Simulated ammunition should be installed in all storage compartments as appropriate.

d. Ensure that reference fuels, lubricants, and antifreeze as specified by relevant NATO authority (after ratification) are available. Until NATO agreement is ratified, developer-specified petroleum, oils, lubricants (POL), and antifreeze will be used.

e. Ensure that appropriate safety and test operating documents are available and distributed to test personnel.

f. Ensure that spare parts, special tools and technical manuals are on hand as appropriate.

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g. Ensure that forms and instructions for data collection are prepared as appropriate.

h. Mount recording instrumentation on each test vehicle to record speed, engine rpm, engine hours, critical temperatures and pressures, etc., if required.

3.2 Test Courses

Maintain a constant severity level of the test courses as much as possible.

3.3 Environmental Conditions

If possible, conduct the test under conditions comparable to all four seasons of the year.

4. TEST PROCEDURE

a. The test profile is usually defined in the vehicle requirements documents and incorporated in the test plan. ANNEXES A and B provide information for consideration on the development of RAM-D test cycles.

b. Maintain course speeds as directed by the test plan, consistent with course conditions, safety and regulatory requirements.

c. Ensure applicable safety regulations are followed throughout the test.

d. Ensure that correct levels of lubricants, hydraulic fluid, coolant, etc., are maintained throughout the test.

e. Record test course data (for example, muddy, dry, dusty) for all periods of operation.

f. The load states of the vehicle and trailer, if applicable, should be specified in the test plan.

g. If the vehicle to be tested has a turret, the turret must be tested in both the combat and travel position.

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h. Perform preventive (scheduled) maintenance as prescribed in the applicable technical manuals or as specified in the Test Plan; perform corrective (unscheduled) maintenance as required to keep the vehicle operational. Record all maintenance data pertinent to reliability, availability, maintainability and durability parameters (see AVTPs 02-10 and 11-20).

Inspect the vehicle at least once during each 8 hours of operation for deficiencies, damage, or unusual wear.

i. When required, take lubricant samples before, during, and after the test for a spectrometric oil analysis.

j. Incorporate authorized engineering modifications as required to eliminate causes of damage or undue wear to the vehicle as soon as practicable, and to gain maximum data on the modification.

k. When required, conduct special tests such as stress and temperature measurements on specific components during the RAM-D operation.

l. Final inspection. After the test, inspect and (if permitted) disassemble the vehicles to the extent required for visual and dimensional inspections of unusual wear or damage to components. If appropriate, record the result using photographs to show the wear and condition of major components.

5. DATA REQUIRED

a. Test course identification/description.

b. Vehicle and major component serial numbers.

c. Applicable payload weight and configuration, break-in mileage, and any post break-in adjustments .

d. Initial and final odometer readings and distance travelled per test course.

e. Vehicle speed record and average speeds for each course (if required).

f. Engine total running time.

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- g. Component operational hours.
- h. Vehicle fuel consumption for the RAM-D test and, if required, each test course mentioned in para 2.1, except other specific courses.
- i. Quantity of lubricants used.
- j. Documentation of failures and failure analyses.
- k. Parts usage data.
- l. Conditions such as road, weather, etc., which affect vehicle performance.
- m. Reliability, availability, maintainability and durability incident data (see AVTP 11-20, COLLECTION OF RELIABILITY, AVAILABILITY, MAINTAINABILITY AND DURABILITY INCIDENT DATA).
- n. Human factors observations.
- o. Data on special tests (as required).
- p. Results of spectrometric oil analysis (if applicable).
- q. Results of final inspection.
- r. Any safety hazards noted.
- s. Vehicle handling/steering problems encountered.
- t. Subjective opinions by experts.
- u. Description of operators and maintainers.
- v. Description of cycles or mission profile.

6. PRESENTATION OF DATA

Present the required data in narrative, graphical, photographic or tabular form as appropriate.

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ANNEX A: DEVELOPMENT OF RAM-D TEST CYCLES

A RAM-D test is used to simulate extended field usage of an item by operating one or more test items over various test courses for prescribed distances and/or times. The length of the test may be, but is not necessarily, equivalent to the rebuild or overhaul interval or the expected useful life of the item. It is usually necessary to accomplish this testing in a compressed time frame and under proving ground conditions. Therefore, the effects of slow processes may not be detected.

A RAM-D test must be as representative as possible of the expected operational role for which the item is being acquired. A representative test may be accomplished by structuring the test in such a way that the test item is operated in cycles based on the usage, tasks, operation, road and terrain types, environments etc., which make up the expected operational role for the item.

The following definitions are useful in designing test cycles to represent field use of a test item:

Operational Mode Summary

A description of the anticipated mix of ways equipment will be used in carrying out its operational role (for both peacetime and war); includes expected percentage of use in each role and percentage of time it will be exposed to each type of environmental condition during the system life.

Mission Profile

A time-phased description of the operational events and environments an item experiences from beginning to end of a specific mission.

Mission Duration

The length of a specific operation assigned to an individual or unit operating the equipment. The mission is distinguishable by a recognized start point and end point and its length is measured in time, distance, or cycles.

Mission-essential Functions

(a) The minimum operational tasks that the system must be capable of performing to accomplish its mission profiles;

(b) a system function which is critical to the success of a mission (STANAG 4158).

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Ideally, if the test item has more than one mission, the RAM-D test will consist of a mix of several different cycles which include all the mission profiles. If the number of test items and/or time is limited, it may be necessary to use the most representative mission or design a cycle which includes the critical portions of different missions. The cycles must be designed to assure that all mission-essential functions are exercised during the test. Usually the cycles will be based on expected wartime missions as these will be the most rigorous. The total test length and/or the total number of cycles must produce a statistically adequate number of miles, hours, operations, missions, etc., as appropriate, to determine compliance with requirements documents if necessary.

The information on which to base the structure of the test cycles can usually be found in the acquisition documents for the item (e.g., requirements documents, operational plans). National standards and the structure of previous tests for similar vehicles must be considered, especially where information for test cycles is not completely known and/or comparison with previous test results is an important objective of the test.

NOTE:

RAM-D test results out of a compressed time frame under proving ground conditions may not be directly comparable with results gained from peacetime or wartime usage.

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ANNEX B: DURABILITY CONSIDERATIONS

Testing for durability is carried out by operating test items under conditions that duplicate field conditions as closely as possible for a period of time which is considered adequate to determine whether the test item will survive to the end of its service life or to its rebuild/overhaul point. Designing a test to determine durability characteristics should take the following elements into consideration:

a. In some instances, the anticipated use of the item may cover such a broad spectrum of environments that it will be necessary to divide the item operational modes into two or more conditional modes due to the change in expected service life related to the environment. If, for example, an item is expected to operate under arctic, tropic, and desert conditions, depending on assignment, these may form the basis for three conditional modes with a separate durability requirement specified for each.

b. A definition of the conditions that represent a durability failure should be developed and approved. This definition must be comprehensive and all-inclusive so that it will be immediately apparent during testing whether an item has sustained a durability failure. The definition of a durability failure must completely and precisely define the conditions that exist at the time of service life termination or rebuild point. The statement may take the form of a limitation on the required level of repair, a catalog of mechanical malfunctions, a value limitation of labor required to correct a malfunction, a limitation of the cumulative cost or man-hours expended throughout the life of an item, or any other criterion or combination of criteria that will ensure there is no ambiguity about when useful life has ended or the rebuild point is reached.

c. The number of items required in the sample should be determined. Sample size is computed on the basis of the durability criteria and desired confidence level. The minimum sample is the number of items that will demonstrate the required durability at the desired confidence level when no durability failures occur before reaching required service life. However two factors complicate durability test design and the analysis of results:

1. If a nonparametric statistical method (e.g. use of binomial tables) is used for test design, the sample size required to predict failure-free performance with an appropriate confidence may be too large to be practical. With wheeled and tracked vehicles usually only small sample sizes are possible because the durability testing requires extended periods of time and destroys or wears out the tested items.

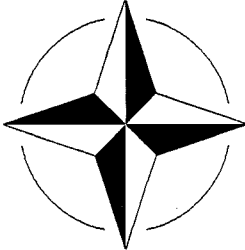
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2. Statistical methods to determine the probability of failure-free performance with an appropriate confidence for small sample sizes require the test item to be operated far beyond the required service life, which may not be practical or reasonable for tracked and wheeled vehicles.

Also, design for the modular replacement of worn or broken parts permits extensive repair at lower maintenance levels in many modern vehicles, extending the useful life. Many items do not have a specific service life or rebuild requirement, or this requirement is for such a long period (e.g., 5 or 10 years of use) that testing is not feasible. If something is known or assumed about the durability failure distribution for a test item, a predictive statistical technique (e.g., Weibull) may be used to infer the interval between durability failures (i.e. the predicted service life) but the limitations of sample size and test time still apply. It may only be possible (and necessary) to predict that the service life is greater than a certain interval demonstrated in test rather than predicting the actual interval to durability failure.

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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : RELIABILITY, AVAILABILITY
MAINTAINABILITY AND DURABILITY
(RAM-D)

TEST TITLE : COLLECTION AND REPORTING OF
RAM-D INCIDENT DATA FOR
WHEELED AND TRACKED VEHICLES

REFERENCE : STANAG 4357
STANAG 4358
STANAG 4158
ARMP 1 - 8

EQUIVALENT : ITOP NO.: 2-2-509 (1)
WEU 4FT6 NO.: TM 11-20

FOR COMPLIANCE
WITH : -

ABSTRACT : This document describes procedures
for collecting and reporting RAM-D
data during endurance or other ap-
propriate tests of wheeled and
tracked vehicles.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: RELIABILITY, AVAILABILITY, MAINTAINABILITY AND
DURABILITY (RAM-D)

Test Title : COLLECTION AND REPORTING OF RAM-D INCIDENT
DATA FOR WHEELED AND TRACKED VEHICLES

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
4. TEST PROCEDURE
5. DATA REQUIRED
6. PRESENTATION OF DATA

ANNEX A: RAM-D DEFINITIONS

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1. SCOPE

a. This document describes procedures for collecting and reporting reliability, availability, maintainability and durability incident data during endurance testing or other appropriate tests of wheeled and tracked vehicles.

b. The main emphasis of this document is hardware-related reliability, availability and maintainability as addressed in NATO STANAG 4158. Operational-related incidents resulting from operator errors or accidents do not enter into the hardware reliability calculation; however, the data is collected and would be available for operational reliability evaluation if required.

c. This document does not address calculation and analysis of RAM parameters (Reliability, Availability, Mean Time to Repair, etc.). Examples of RAM calculations are provided in AVTP 00-09, General Evaluation Procedures.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Endurance test courses (See AVTP 11-10).

b. Maintenance facilities (See AVTP 02-10).

2.2 Instrumentation

The instrumentation required is that which is used for RAM-D testing (See AVTP 11-10). Additionally, use:

DEVICES FOR
MEASUREMENT OF:

PERMISSIBLE ERROR
OF MEASUREMENT*

Maintenance and diagnostic time

5 %

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

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3. REQUIRED TEST CONDITIONS

- a. Ensure that the vehicles have been prepared in accordance with RAM-D test procedures (See AVTP 11-10).
- b. Ensure that the maintenance facility has all the common and special tools required by the maintenance manuals for the vehicle under test.

4. TEST PROCEDURE

- a. Operate test vehicles in accordance with the RAM-D test procedure (AVTP 11-10).
- b. Ensure that maintenance and service operations are performed in accordance with the maintenance manuals and at prescribed intervals.
- c. Report each incident on the test vehicle(s) in an Incident Report. A separate report will be made for each unrelated incident. Incident Reports can also be used for reporting engineering investigations, comments on technical manuals, suggested improvements, and other events concerning the test and the test vehicle(s).
- d. Record man-hours and clock-hours for each maintenance action (include diagnostic time). Report maintenance man-hours and clock-hours to nearest tenth (0.1) of an hour.
- e. Classify each incident using the specific Failure Definition/Scoring Criteria (FD/SC) for the vehicle, or use NATO STANAG 4158.

5. DATA REQUIRED

For each incident:

- Date and time of occurrence
- Prevailing weather and test course conditions
- Odometer reading
- Engine hour meter reading
- Part name and number of item(s) affected by the incident
- Part name and number of item(s) which caused the incident

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- Action taken on affected item(s) if not replaced
- Subsystem identification code
- Incident description
- Incident classification per vehicle failure definition or NATO STANAG 4158
- Maintenance level
- Maintenance description - to include function controls and adjustments
- Parts replaced
- Diagnostic man-hours and clock hours
- Maintenance man-hours and clock hours
- Accumulated test time and distance to failure
- Special skills required
- Special tools required
- Subjective opinions by experts

6. PRESENTATION OF DATA

The required data will be presented in narrative, tabular, graphical or pictorial form as appropriate. Special forms (Incident Reports) may be prepared with specific areas for each item of required data.

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ANNEX A: RAM-D DEFINITIONS

(See also Allied Reliability and Maintainability
Publication - ARMP)

1. Reliability

The probability that an item will perform its intended function for a specified variate quantity, e.g., time, distance or number of operations, under stated conditions.

2. Availability

A measure of the degree to which an item is in an operable and committable state at the start of a mission when the mission is called for at an unknown (random) time.

3. Maintainability

A measure of the ability of an item to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources.

4. Durability

A special case of reliability; the probability that an item will perform its intended function without a durability failure for a specified variate quantity, under stated conditions where the "specified variate quantity" is the expected or required service life or rebuild/overhaul point of the test item.

NOTE: Reliability and durability are similar mathematical measures with precise but different meanings. Care must be taken not to interchange them.

5. Durability Failure

A failure that precludes further operation of the test item (which may be the end item or a selected major component) and is so serious (in terms of cost, safety, or time to restore, for example) that the item must be discarded or replaced before reaching the end of the expected or required service life or rebuild/overhaul point. The following wear-out criteria may also be considered appropriate for a durability failure:

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- (1) failures that have become abnormally frequent and time-consuming to repair.
- (2) deterioration such that further maintenance efforts to retain the item in serviceable condition are not warranted.

6. Scheduled (Preventive) Maintenance

All periodic, prescribed maintenance actions, such as inspecting, servicing, adjusting, and replacing components on the basis of time, distance, cycles of operation or mission event, performed to retain an item in a specified condition.

7. Unscheduled (Corrective) Maintenance

All actions which are not planned on a periodic basis but are required to repair actual or impending failures to restore an item to a specified condition. These actions include diagnosis, disassembly, interchange, reassembly, alignment and checkout.

8. Incident

- a. The occurrence or detection of any degradation, interruption, or loss of a function (STANAG 4158);
- b. An event, other than normal operation, leading to any activity performed on the test vehicle(s), whether scheduled or unscheduled, including modifications and pre- and post-test inspections.

NOTE: Definition b. expands the definition of "Incident" in NATO STANAG 4158 to include recording of non-failure events.

9. Incident Classification

Evaluating an incident occurring during the test in accordance with the vehicle Failure Definition/Scoring Criteria or NATO STANAG 4158. Incidents are classified as No Test, Not Relevant, Maintenance Relevant (scheduled maintenance) or Failure (mission and non-mission). The man-hours and clock-hours for No Test and Not Relevant incidents are not included in the calculation of hardware RAM-D parameters. Examples of incidents/actions where the time is not chargeable are:

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- a. Maintenance occurring during the pretest checkout and break-in period.
- b. Equipment modification such as replacement with redesigned components, or installation of hardware kits (except when component is malfunctioning or not operating).
- c. Correction of malfunctions caused by non-system equipment or people not acting as crew or maintenance personnel.
- d. Maintenance to correct results of abuse, damage from accidents, or improper or insufficient maintenance.
- e. Non-RAM-D-oriented events, such as: suggested improvements, reports, and inability to meet performance specifications even though no malfunction has occurred.
- f. Unjustified replacement of functional parts.
- g. Manufacture of special spare parts which are not available under normal conditions.

NOTE: Premature replacement of parts, whether or not based on an alleged impending failure, is not permitted except when authorized, and is so recorded on an incident report. When such action is authorized, the maintenance is chargeable.

The diagnostic and maintenance time recorded for incidents classified as Maintenance Relevant and Failure (mission and non-mission) is used in the calculation of RAM-D parameters. The diagnostic and maintenance times are assigned to the appropriate levels of maintenance.